Space Weather Technical Forecast

Issued on Monday, 11 September 2023 at 01:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-flares likely (R1-R2 radio blackouts). Chance of G1 Minor storms Day 2 (12 Sep) due to HSS arrival from CH44.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low, with a peak flare of C8.3 at 10/0155 UTC, originating from AR3423 near centre disc. There has been an increase in the number of observed spots on the disc with thirteen now visible, although three of these will rotate away over the northwest limb during the next 24 hours. AR3423 in the centre disc remains the largest group, and main flare source. This is comprised of a number of mature spots with penumbra, including a large trailer and seen ongoing slow development, although the overall areal extent appears to have now stabilised. Despite a number of spots emerging in the southern disc, they are predominately small and simple, with AR3431 the main one of interest. This is currently a small, still developing region, but is a compact bipolar cluster with some evidence of an east-west component to its parity separation line, and subsequent potential instability.

No Earth-directed CMEs have been observed in available coronagraph imagery, with a bright CME off the northwest assessed as far-sided.

Solar Wind / Geomagnetic Activity: Slow wind was observed at L1 by ACE/DSCOVR throughout. Background speeds of around 350km/s were observed, with density remaining below average. The Interplanetary Magnetic Field (IMF), Bt, was weak and below 7nT throughout with north-south component, Bz, mainly positive until 11/1400 UTC, but then more variable. This ranged+/- 5nT. Phi angle was mostly negative (towards the Sun). Geomagnetic activity was Quiet (Kp 0-1).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux has been at background. GOES16 high energy (greater than 2MeV) electron flux was at background. The associated 24-hour fluence was well below the Active threshold, with 2.38e6 integrated pfu observed at 11/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to remain mostly Low but with isolated M-class flares likely, mostly from AR3423 and developing AR3431.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs. The coronal hole and subsequent solar wind forecast is low confidence. This is due to a lack of enhancement from CH44/+ from a similar position on the previous rotation. However this feature is in a good location for a high speed stream (HSS) to arrive at Earth, most likely day 2 (12 Sep), with solar winds 550km/s. Enlil is also reducing confidence with a much stronger and earlier arriving coronal hole, but from a more central located, perhaps related to CH46/-. This feature is not expected to enhance winds at Earth, however an enhancement, is likely form CH47/-, currently just west of centre disc, most likely late on day 3 or day 4 (13-14 Sep). This would be in agreement with observed conditions on the last 27-day rotation, despite this feature being less visible on that occasion. Overall, the current forecast is for HSS enhancement day 2, with current Quiet geomagnetic activity becoming Unsettled to Active with a chance of G1 Minor

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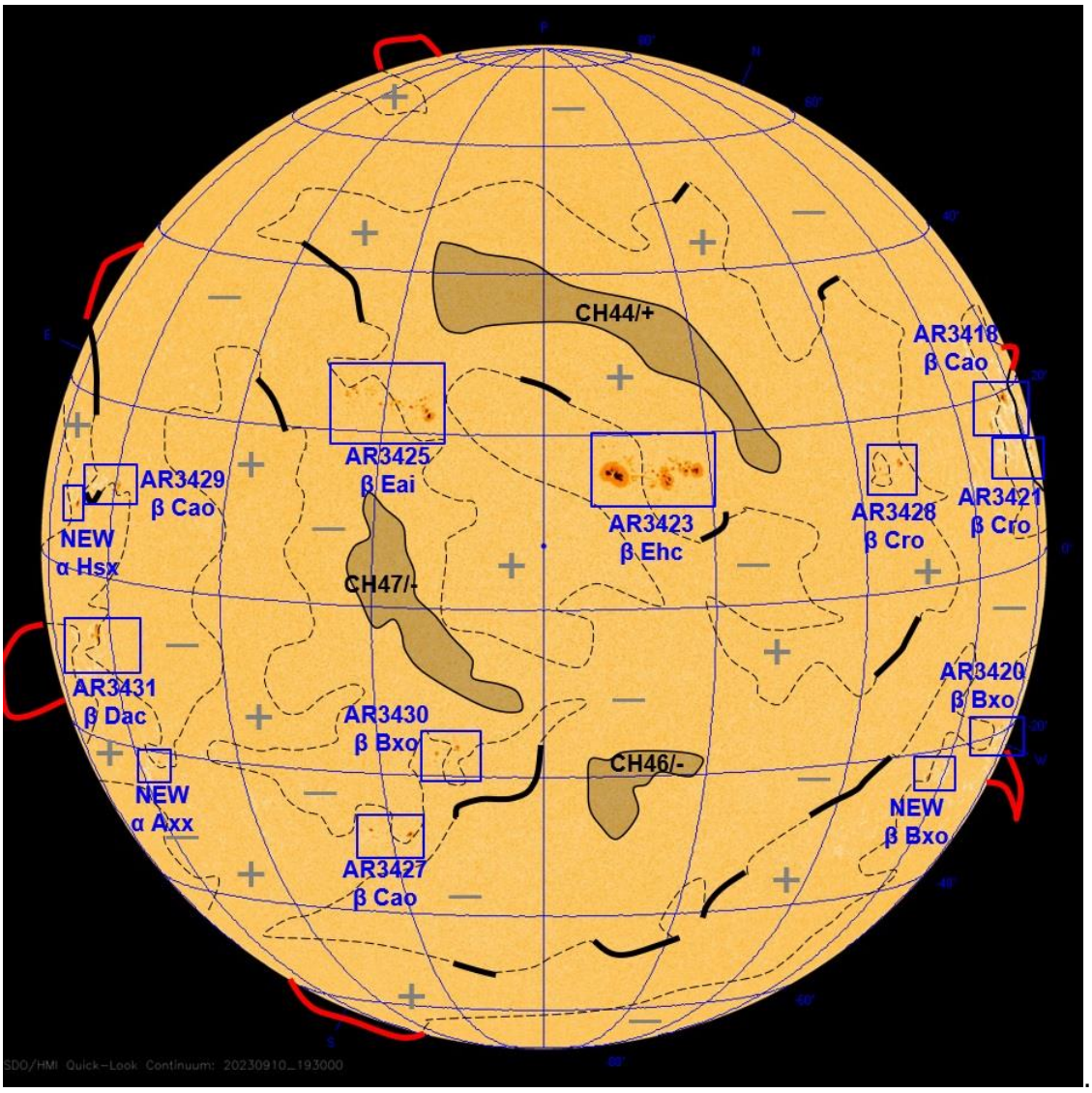
Storms. This will likely ease to Quiet to Unsettled day 3 (13 Sep), with a subsequent enhancement late day 3 or day 4 (13-14 Sep), bringing a chance of Active intervals.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to remain at background levels, with a very slight chance of an enhancement should any larger flares occur. High energy (greater than 2 MeV) electron flux is expected to be at background day 1 (11 Sep), then likely responding to the fast wind arrival, and increasing to Moderate to High later day 2 and day 3 (12-13 Sep). Confidence is then Low, however any subsequent solar wind enhancement has the potential to drop out value later day 3-4 (13-14 Sep). Overall, the fluence is expected to remain below the Active threshold, but with a slight chance of rising above later in the period.

Figure 1. Solar Analysis Valid 10/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are currently no Earth-directed CMEs, with the CME from the 05 Sep having missed.

CH44/+ in the northeast disc is a prominent feature on the disc, and the most likely source of significant enhancement, however there are a number of factors lowering confidence in the forecast. Based upon a HSS speed of 550km/s, onset of this feature could be as early as late day 1 (11 Sep), but more likely day 2 (12 Sep). However, this feature was present on the Sun on the previous 17-day rotation and yet Earth saw no enhancement from its associated HSS.

Furthermore, Enlil, while it does have an enhancement through day 1-2 (11-12 Sep), this appears to be from a more southern or centrally located hole. This is potentially CH46/- in the southern disc, however comparison with 27-day persistence shows that Earth also saw no enhancement from this feature, with the main enhancement on the previous rotation on the equivalent of late day 3 and into day 4 (13-14 Sep). While this did have a negative phi angle, this was likely due to a small crack in the corona, which has subsequently developed into CH47/-.

Consequently current Quiet conditions are expected to continue until the arrival of any CIR associated with CH44/+, most likely day 2 (11 Sep). As Earth is now slightly further north in solar latitude compared to the previous rotation, and given the persistence of the hole, and its Russel-McPherron favoured polarity, a spell geomagnetic disturbance is likely. Unsettled to Active Geomagnetic activity is forecast, with a chance of G1 Minor Storms. Activity then easing to Quiet to Unsettled day 3, before a further enhancement is possible, most likely late day 3 or day 4 (13-14 Sep) with a transition into any fast wind from CH47/- bringing further Active intervals, and a slight chance of G1/Minor Storms.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	30	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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Figure 2a: SDO aia-211 of last rotation (left) and current (right)

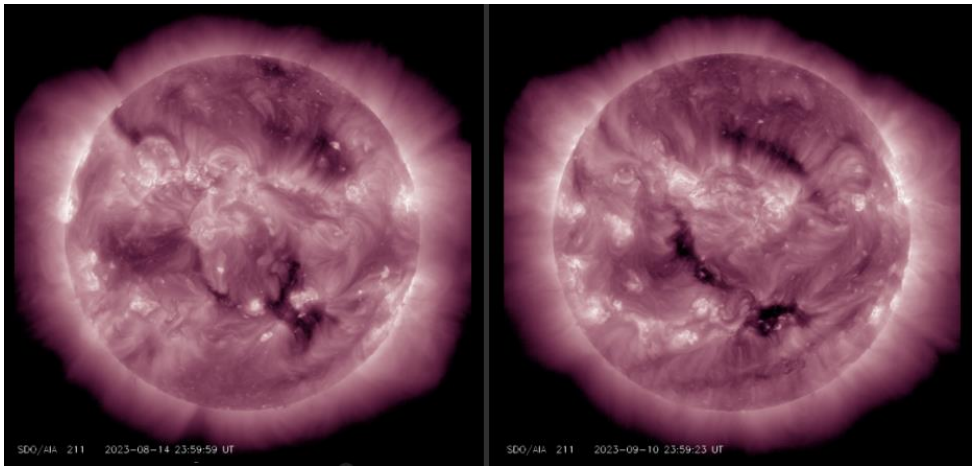


Figure 2b: Solar Wind Persistence Model, showing only enhancement day 4 – however this coincides with negative phi angle on last rotation.

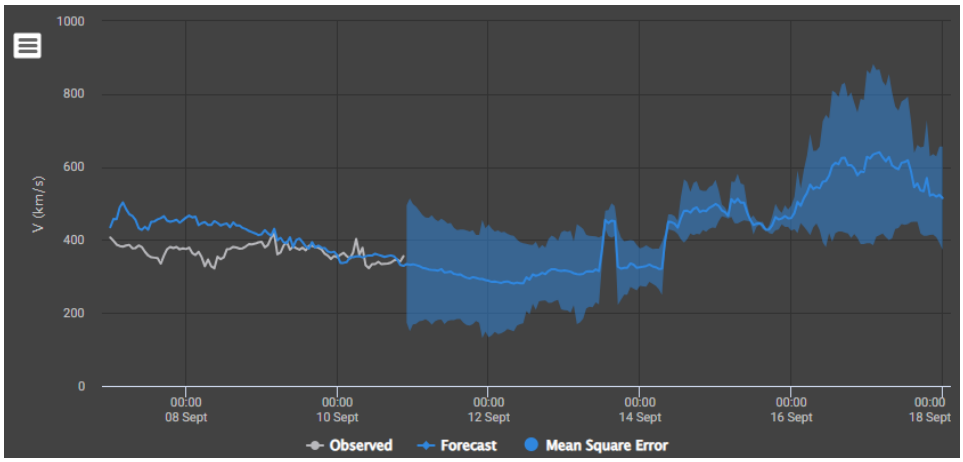
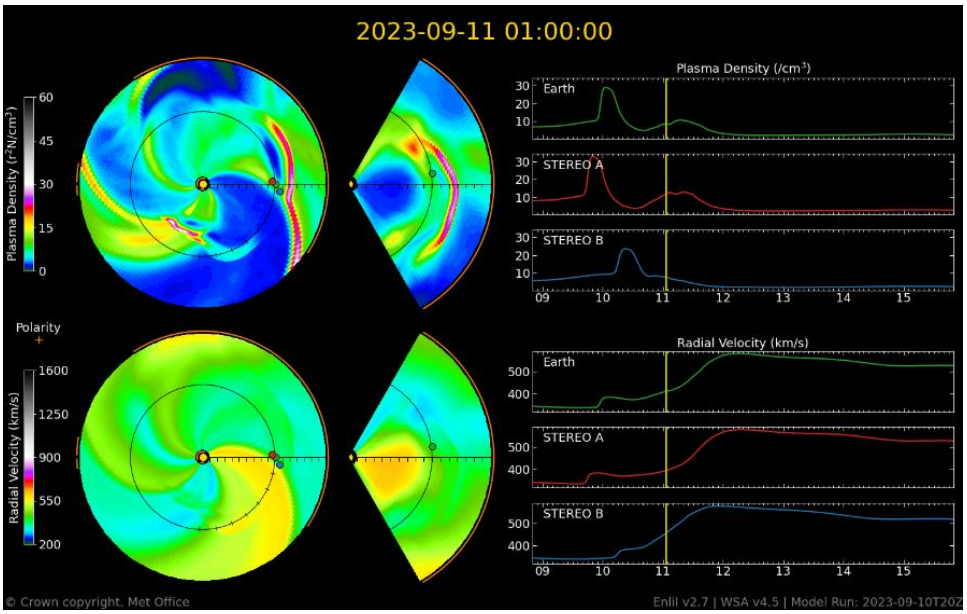


Figure 2c: Enlil showing strong enhancement on day 1 (11 Sep) – but centre/south source.



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Radio Blackouts - X-Ray Flares:

Solar activity is expected to be at Moderate to Low levels, with isolated M-flares likely through the period.

There has been a recent uptick in sunspot numbers, with thirteen sunspots currently on the disc. The majority of these are small and simple. Three of these regions are also close to the west limb, and expected to rotate off the disc through the next 24 hours. AR3418/21 in the north and recently re-emerged AR3420 in the south. AR3423 persists as the largest region, just west of north-centre disc, and was the source of the largest flare, C8.3, in the last 24 hours. This has continued to see some slow development of spots within its intermediates, although its overall area appears to have stabilised. Further C or isolated M-flares are likely from this region. The other larger region is AR3425 in the northeast, and is composed of a collection of smaller spots, and showing little sign of any further growth.

The main new region of interest is AR3431 in the southwest. This has recently as a small but compact region, with an east-west component to its parity separation line, which is often indicative of increased instability. This was also the source of a C4 flare at 10/2147 UTC. Further development of this region is likely, and this further increases the potential for isolated M-flares. The other new regions on the disc are generally smaller and simpler with a smaller chance of flare activity.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	60	60	60	60
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3a: GOES-16/17 X-ray flux

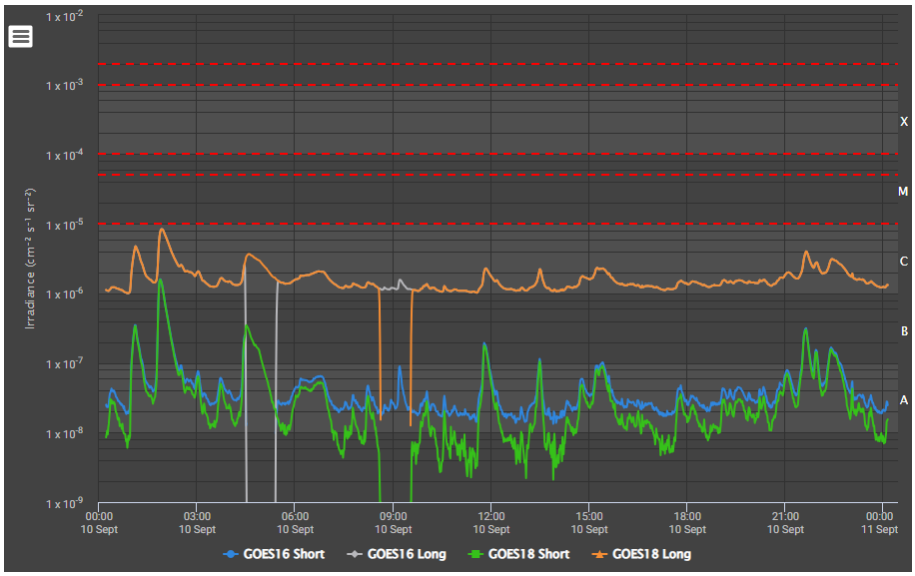

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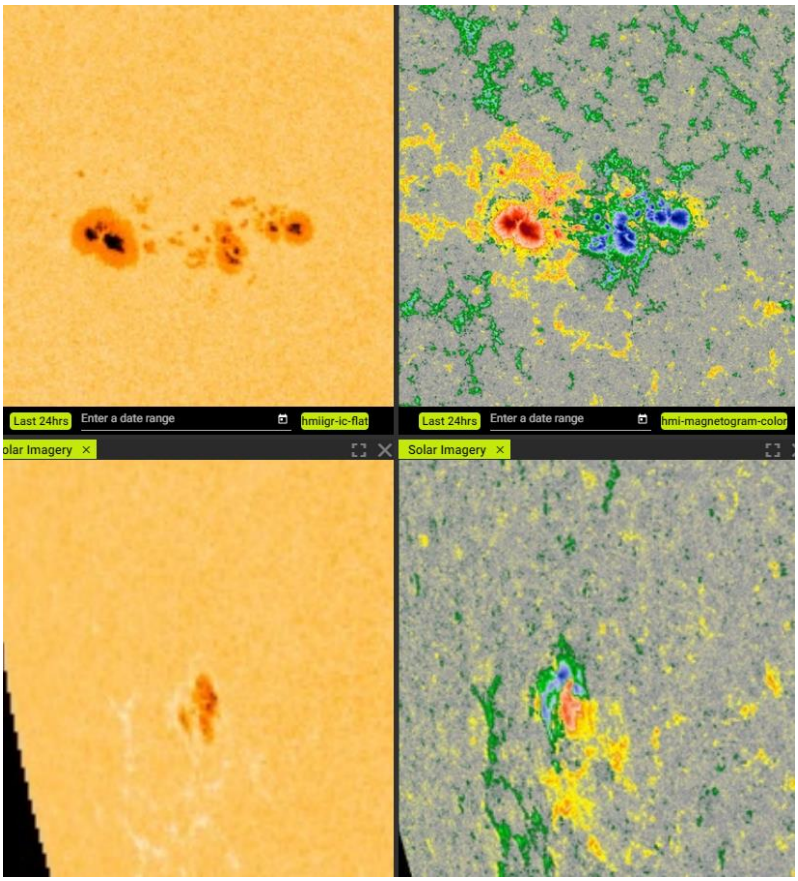
Figure 3b: SDO hmi-intensitygram and magnetogram of AR3423 (top) and AR3431 (bottom)



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is expected to persist at background levels. There remains a very slight chance of flux levels rising in response to any significant flaring, most likely later in the period as AR3423 and AR3425 move across the western hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electron flux observed by GOES-16 is expected to remain at background day 1 and into day 2 (11-12 Sep). Any coronal hole fast wind arrival from CH44/+ has the potential to increase electron flux through the Van Allen belts, and observed values at GEO are likely to increase later day 2 and day 3 (12-13), rising to Moderate, perhaps High at diurnal peak. However this rise is low confidence, with the potential for further solar wind enhancement to disrupt the belts, and leading to a drop out later day 3 or day 4 (13-14th).

The associated 24-hour fluence will most likely remain below the Active (1e8 integrated pfu) threshold. Confidence for this decreases day 3 and day 4, with a slight chance of rising above due to any fast wind enhancement on day 2 (11 Sep) from CH44/-. MOSWOC REFM is considered to be giving good guidance until the onset of any fast winds.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	10	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES-16 >10MeV Electron flux and fluence with REFM and Recurrence

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